Single Event Effect Test Report:

Heavy Ion Irradiation of the 74AC14 Hex Inverter

For: Grace Project

by

Leif Scheick

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I. Introduction and Overview

This report describes the testing of a CMOS Hex Inverter at the Texas A&M Cyclotron facility (TAM). This section describes the basics of the test. The description of the TAM test area and beams lines are contained in section II. Section III contains the test setup and conditions of the test. Section IV contains the results and analyses and the conclusion is in section V.

The purpose of this test was to determine the SEL characteristics of a hex inverter under heavy ion radiation. The cross sections of the device as a function of ion Linear Energy Transfer (LET) was the primary goal. The SEL threshold of this device was also determined. Another observation was any long term or total dose effects from the ion radiation.

A table of the device parameters is shown in Table 1.

Table 1~~1~~. The devices tested in this study.

Device	Manufacturer	Width	Code	Technology	SNs
74AC14		6 Bit			4289, NSN

II. Facility Overview

The SEU test facility at the Texas A&M cyclotron is located on the main campus of the university. The DOE and the State of Texas jointly support the facility. Institute staff constructed, and now operate, a K500 superconducting cyclotron and its advanced Electron-Cyclotron Resonance (ECR) ion sources. The facility was designed to provide a user friendly and efficient testing station for SEE studies. The ECR Ion Source is highly charged ions for injection into the cyclotron are produced by electron-ion collisions in magnetically confined plasma excited by microwave radiation. These ions are also used for atomic physics experiments on an adjacent high vacuum beamline.

The cyclotron has a dedicated SEE Testing Facility which is designed for advanced radiation testing of Very Large Scale Integrated (VLSI) circuits This facility features a large-volume target chamber with a versatile target positioning assembly, and a variety of industry standard vacuum feed through connectors. The chambers upstream from the target chamber provide for the beam control, diagnostic and dosimetry measurements. A large variety of high-energy beams covering a broad range of LETs have been developed specifically for this purpose. These beams have a high degree of uniformity over a large cross sectional area. More information can be found at http://cyclotron.tamu.edu/.

The accelerator provides a wide range of ions and energies for SEE testing. Ion species can be changed in approximately 180 minutes while ion energies cannot be changed mid-run. The ions interact with the target in an approximately 10^{-4} torr chamber. The chamber can be depressurized and evacuated in approximately 15 minutes when a device change is desired. Adjustable degraders vary the LET between the values shown in the third and fifth columns. Tilting the device with respect to the beam allows the effective LET of the device to gain a factor of two. A list of ions used in this study is shown in Table 2.

The interior of the chamber is electrically connected to the test area through an airtight bulkhead. The board on which the Devices Under Test (DUTs) reside is mounted on a moveable stage. The DUT maybe be moved in any of three directions. The DUT may also be rotated. A rectangular iris can changed the diameter of the beam from 0.1

cm to 4 cm in either direction. The DUT can be completely positioned in the beam from the user console and all positioning information is automatically logged.

The calculation of the beam LET and range in a desired material is done automatically for each run and saved. Other saved information is the energy, fluence, and time of the run as well as the angle. The system recalculates the LET and adjusts for the fluence when the angle is changed. Hardcopies can be made for redundancy.

Table 2

Particle	Energy (MeV)	InitialLET(Si) (MeV cm^2/mg)	Range [μm]	LETmax (MeV cm^2/mg)	Range (LETmax) [μm]
Ne	546	1.74	799	9.65	790
Ne	799.5	1.2	1655	9.65	1648
Ar	1000	5.41	500	20.1	491
Ar	1598	3.8	1079	20.1	1070
Kr	2100	19.2	336	41.4	315
Kr	3120	14.2	622	41.4	610
Xe	3200	37.9	286	63.4	254

III. Test Setup and Procedure

The test was comprised of two PCs, a power supply, and a specially designed test board. One PC controlled a HP6629A power supply. This allowed precision voltage control and latch-up detection and protection since the PC had millisecond control over the operation of the power supply. Latch-ups were recorded in a separate file. The nominal current draw for the setup was less than 1 mA and the latch threshold was 5 mA.

There are two levels of latch-up protection for the device when it experiences latch-up. First, the power supply will pull down the voltage within 100 microseconds if the current exceeds a pre-programmed level, Ips. Second, the software cycles power off with 300 to 600 ms when the current exceeds a set threshold level, Isw. In order to preserve the DUTs and collect reasonable statistics, Ips was set at 0.2 A, and Isw was set at 100 mA. If Isw is set higher that Ips, the software never recycles power because the threshold is never reached. This is how a destructive, i.e. does the latch burn out the device, latch test is done. For the part, the destructive latch test was configured as Ips = 1.9 A and Isw = 2A.

A dedicated PC controlled the test circuit board designed specifically for this test to read and write to the DUT. This setup allows complete freedom to interact with the

DUT. This would allow for any structure in the SEEs or predilection for certain pattern failure or type of SEU to be seen. A depiction of the setup used is shown in Figure 1.

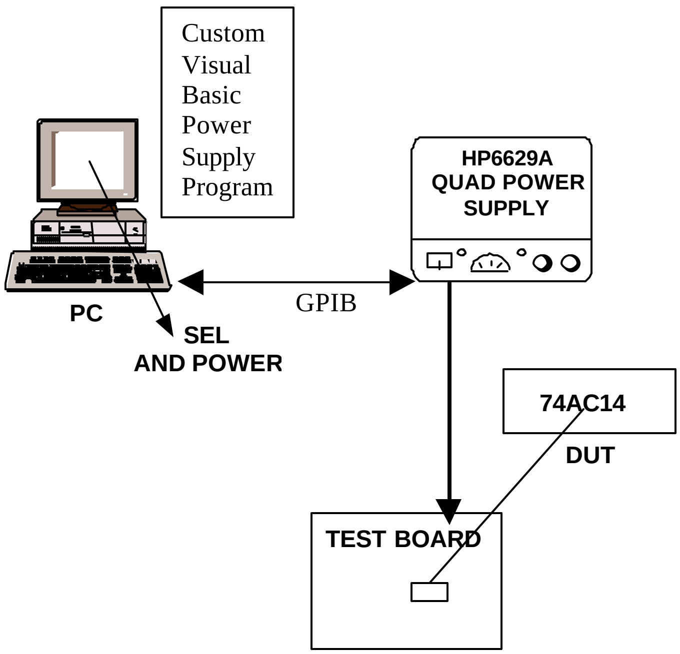

Figure 1~~1~~. A schematic of the test system.

<u>IV. Results</u>

SEL

The device did not experience Single Event Latch-up at any LET up to 75 MeV-cm2/mg.

V. Conclusion

The results of the testing are shown in Table 3. The device is immune to SEL.

Table 3.

Device	SEL Threshold (MeV cm^2/mg)	SEL Saturation Device Cross-section[cm^2]	SEU Threshold (MeV cm^2/mg)	SEU Saturation Device Cross-section[cm^2]
74AC14	>120	N/A	Not tested	N/A